Ship Effects in Navigation Channels

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Effects of Ship Movement

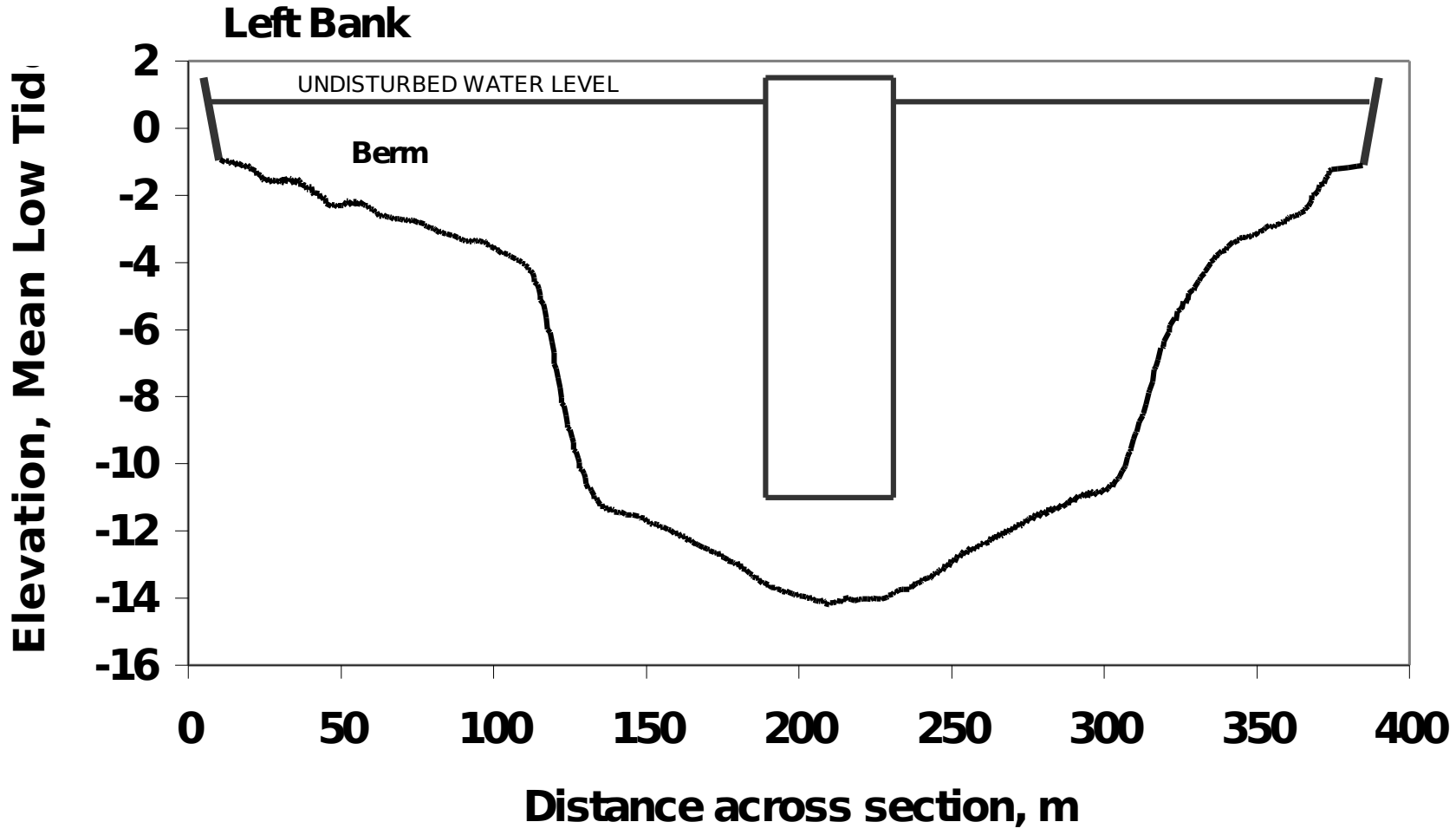
- Environmental Effects
  - Propeller scour (Boston Harbor, Brazil)
  - Entrainment of organisms
  - Disruption of shallow water habitat
  - Resuspension of sediment (Sabine Neches)
- Forces on Moored ships (Atkinson Island, Green's Lake)
- Safety (Tolchester)

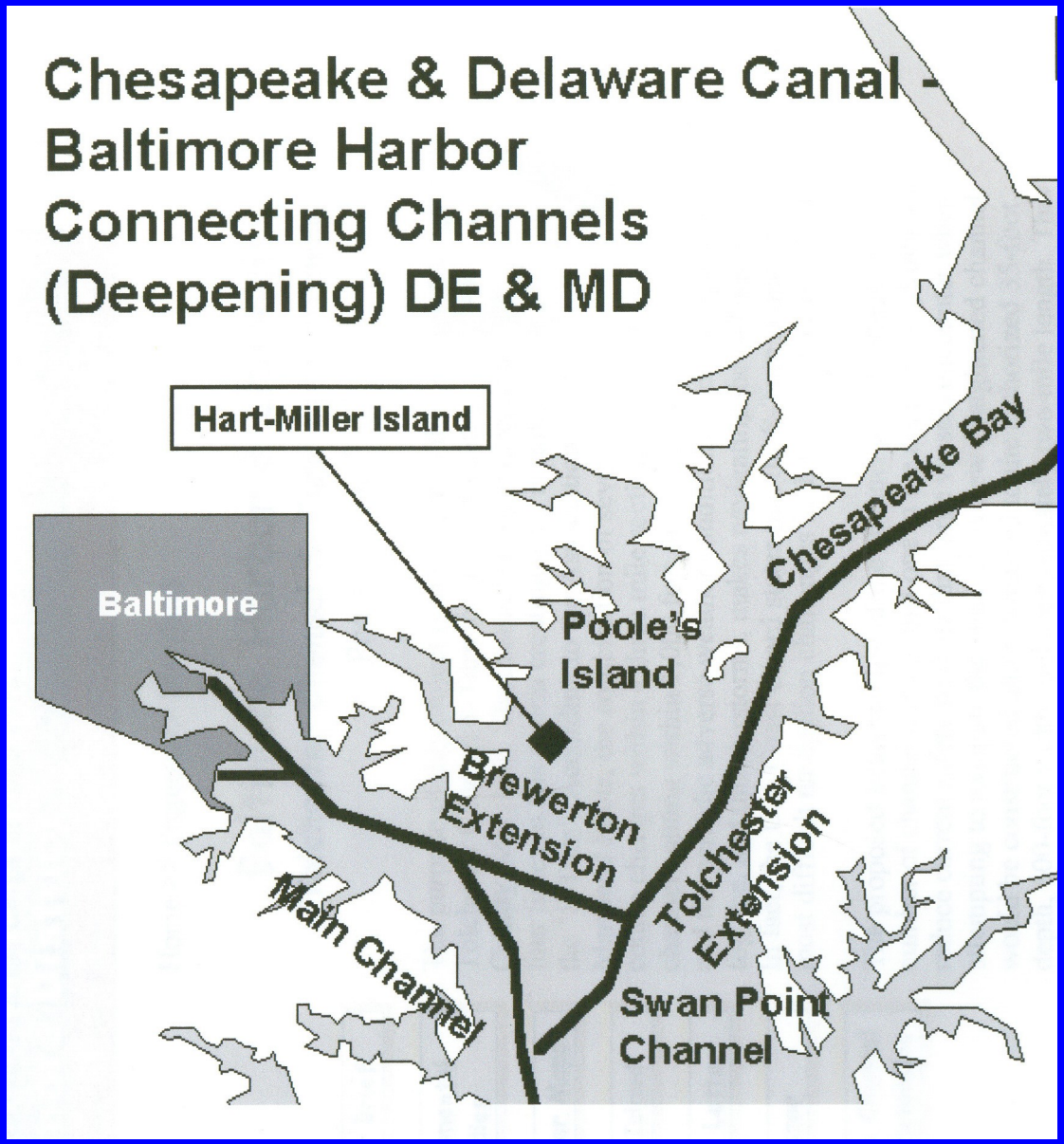
Effects of Ship Movement cont'

- Bank Erosion and Protection
  - Houston Ship Channel, Sabine Neches, Tolchester
  - Hydraulic and geotechnical issues must be addressed (drawdown)
- Some US channels to be deepened, widened, and/or straightened.

Navigation Channels

- Confined or Restricted- BR $= A_{ship} / A_{channel}$ Generally > 0.05-0.1, Sabine Neches, MRGO
- Mixed- Channel confined on one side, unconfined on the other, Tolchester
- All of the above- HSC
- Typical feature- shallow berm adjacent to navigation channel


Left Bank
UNDISTURBED WATER LEVEL
Berm
Elevation, Mean Low Tid
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
50
100
150
200
250
300
350
400
Distance across section, m


Chesapeake & Delaware Canal -
Baltimore Harbor
Connecting Channels
(Deepening) DE & MD
Hart-Miller Island
Baltimore
Poole's
Island
Chesapeake Bay
Brewerton
Extension
Tolchester
Extension
Main Channel
Swan Point
Channel

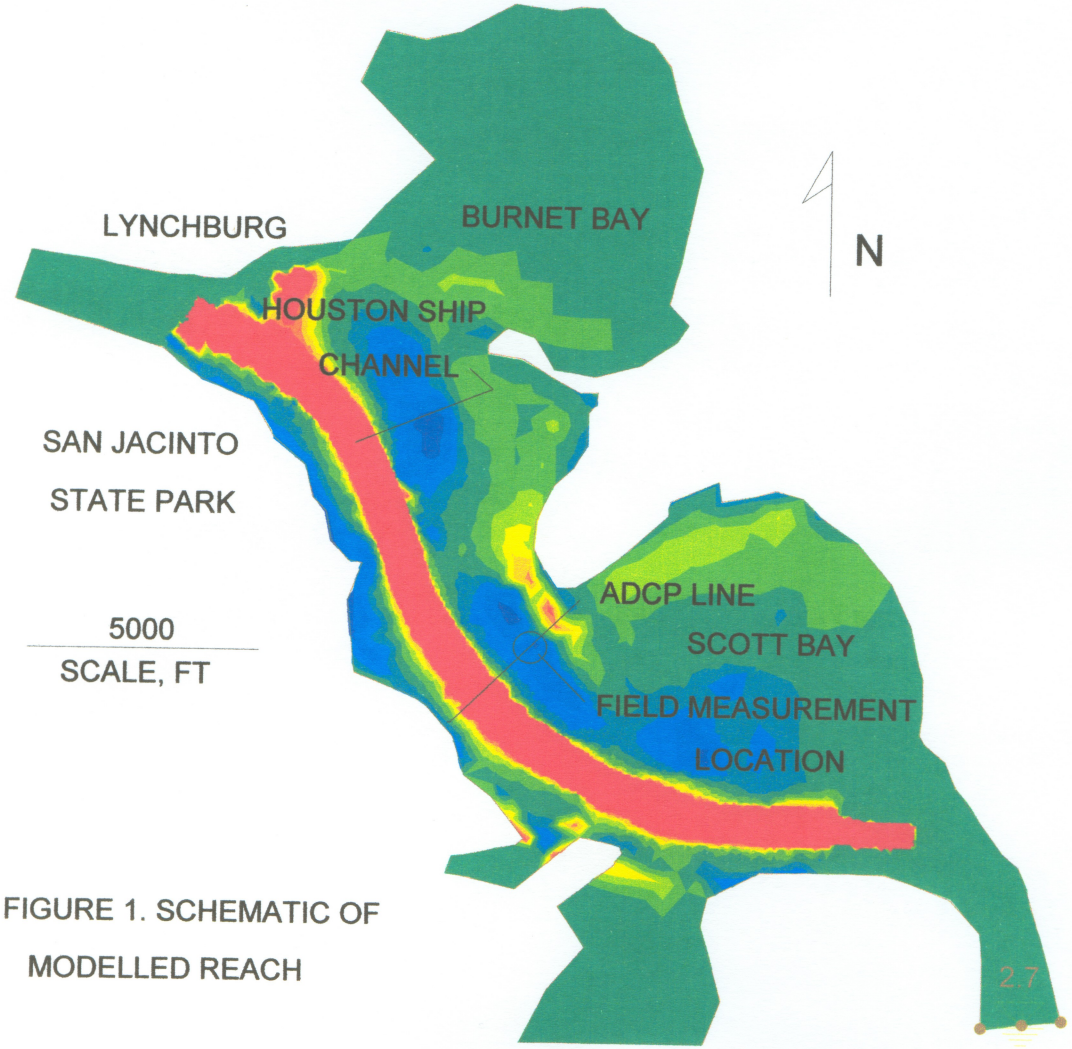


FIGURE 1. SCHEMATIC OF MODELLED REACH

Vessel Types in Deep Draft Channels

- Ships- 800 ft X 140 ft X 40 ft draft typical
- Tugs
- Towboats and barges
- Workboats
- Shrimp boats
- Recreational boats
- Unloaded large ship often worst case

ATHENS 2004

Ship Effects at Bankline

- Long Period
  - Drawdown
  - Surge
  - Transverse Stern Wave
  - Return Velocity
- Short Period
  - Secondary Waves at Bow and Stern
  - Surge Waves (Dand and White)
  - Propeller Jet (small at bankline)

Long Period-Drawdown

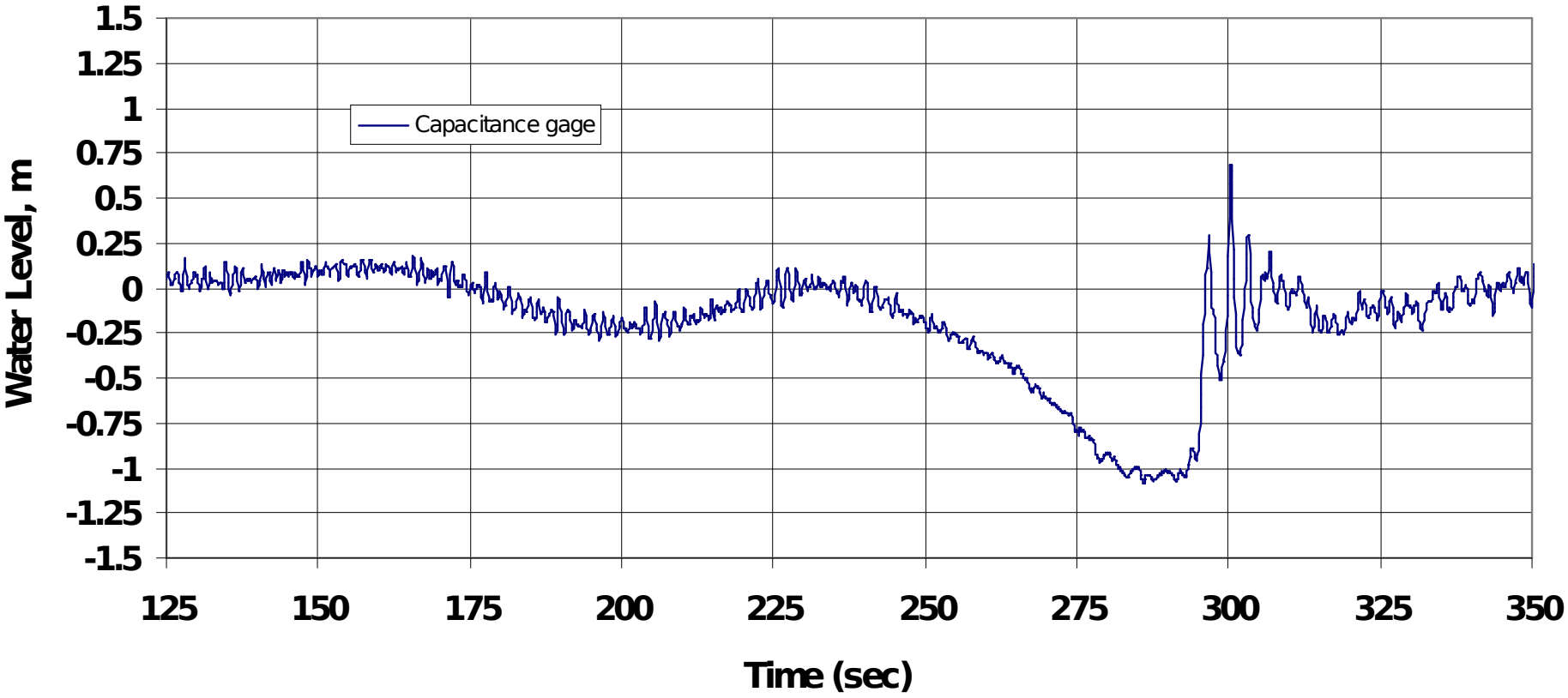
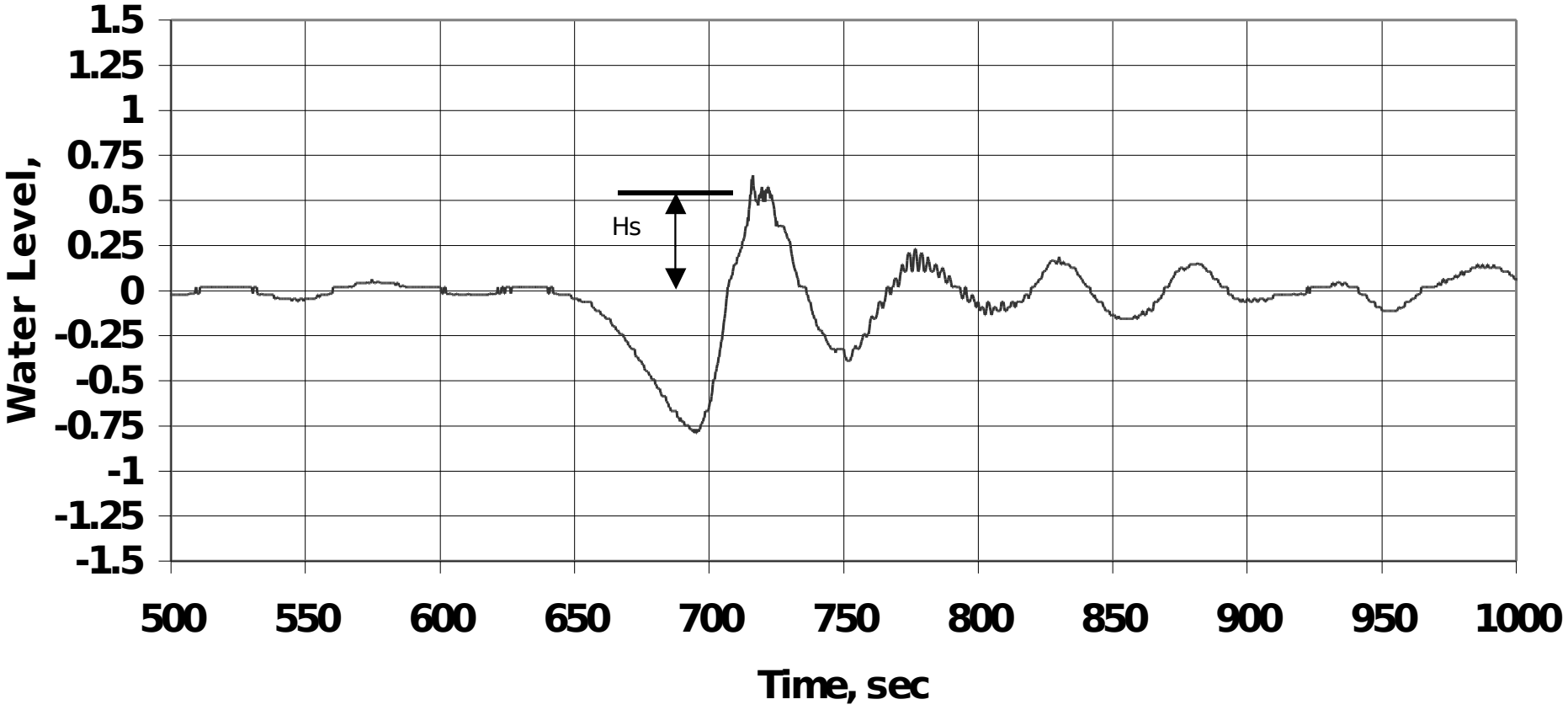


Figure __. Water Level for Pacific Sapphire, Inbound, Time 0 = 1300, 1 May 2002, Capacitance Gage 50 ft from bank, Existing Channel, South Site.

Surge- Kite Arrow, 11.7 knots



WATCH
FOR DEBRIS
ON ROAD
NEXT

Effect of Surge

Transverse Stern Wave

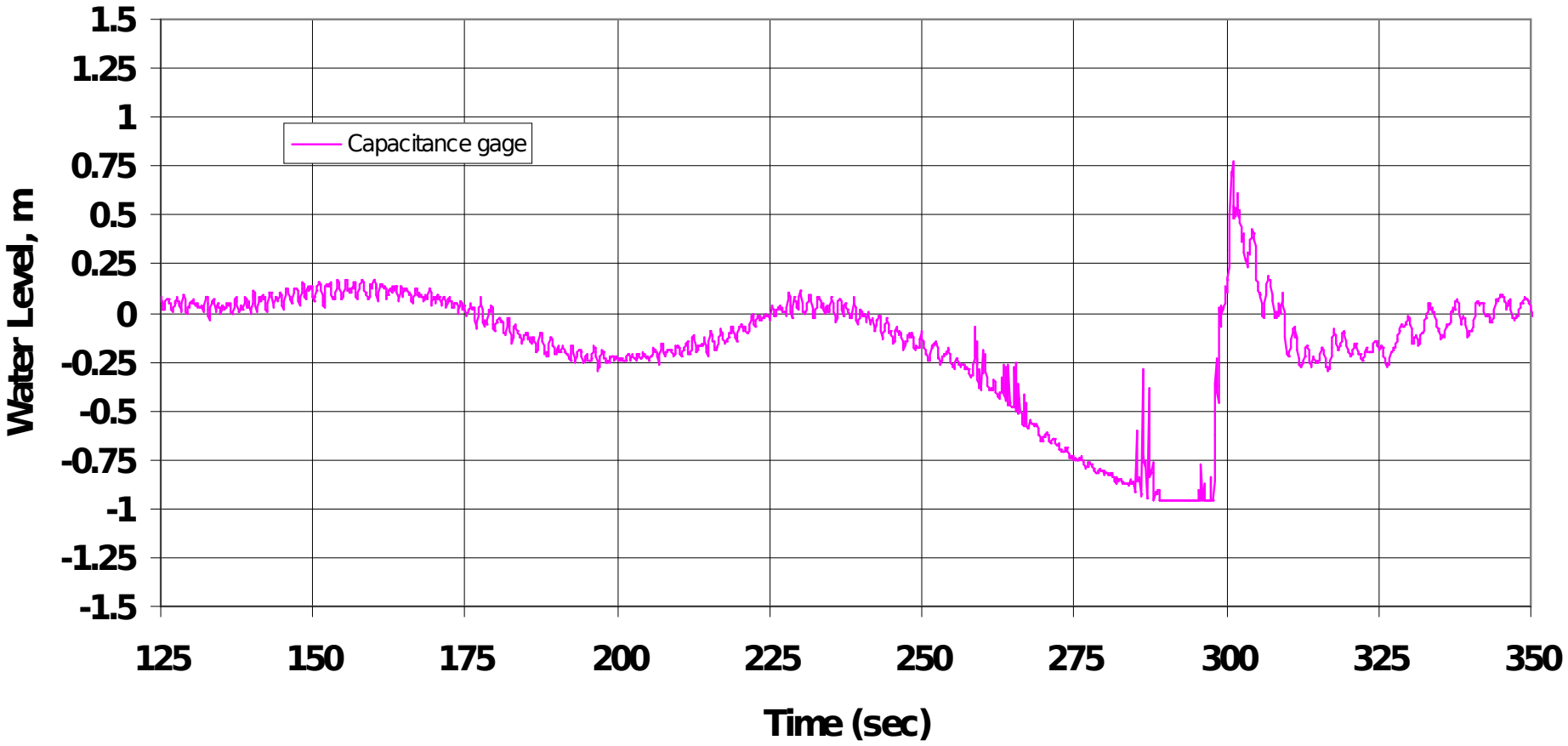


Figure __. Water Level for Pacific Sapphire, Inbound, Time 0 = 1300, 1 May 2002, Bankline Capacitance Gage, Existing Channel, South Site.

Transverse Stern Wave, SDWSC

Transverse Stern Wave Cont’

801 X 138 X 30, 10.3 knots

Transverse Stern Wave cont’

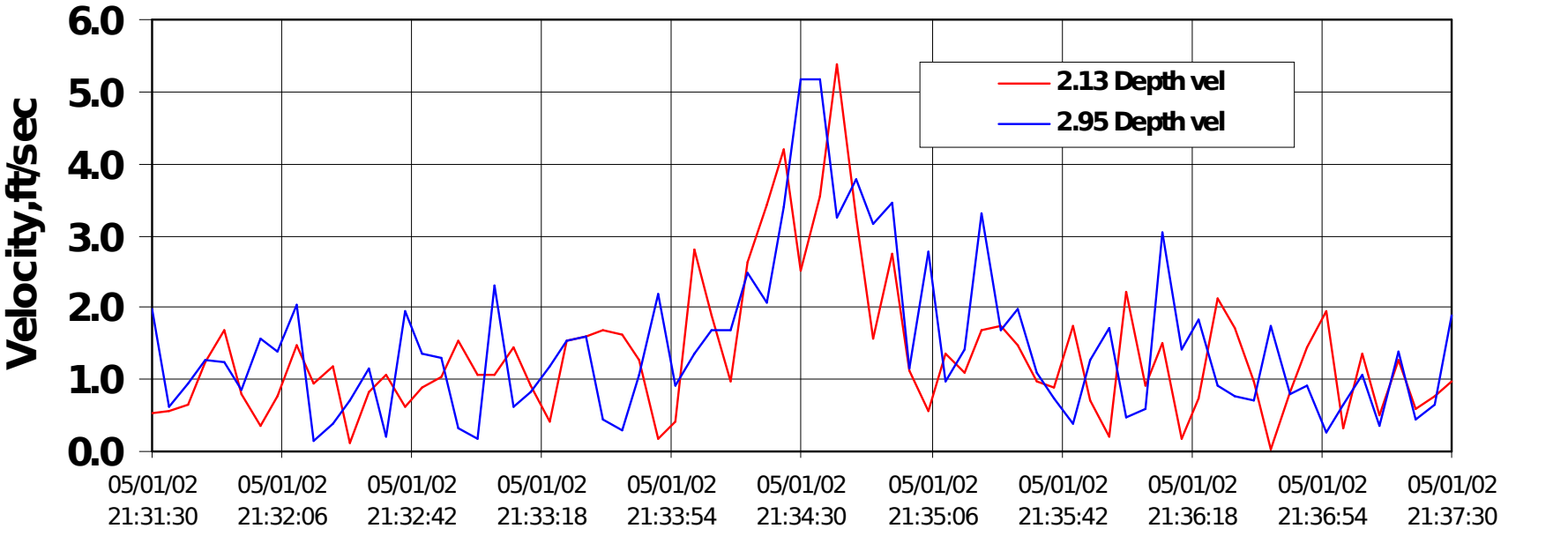
Transverse Stern Wave cont'

Transverse Stern Wave cont'

Transverse Stern Wave cont'

Transverse Stern Wave. How large can TSW be?

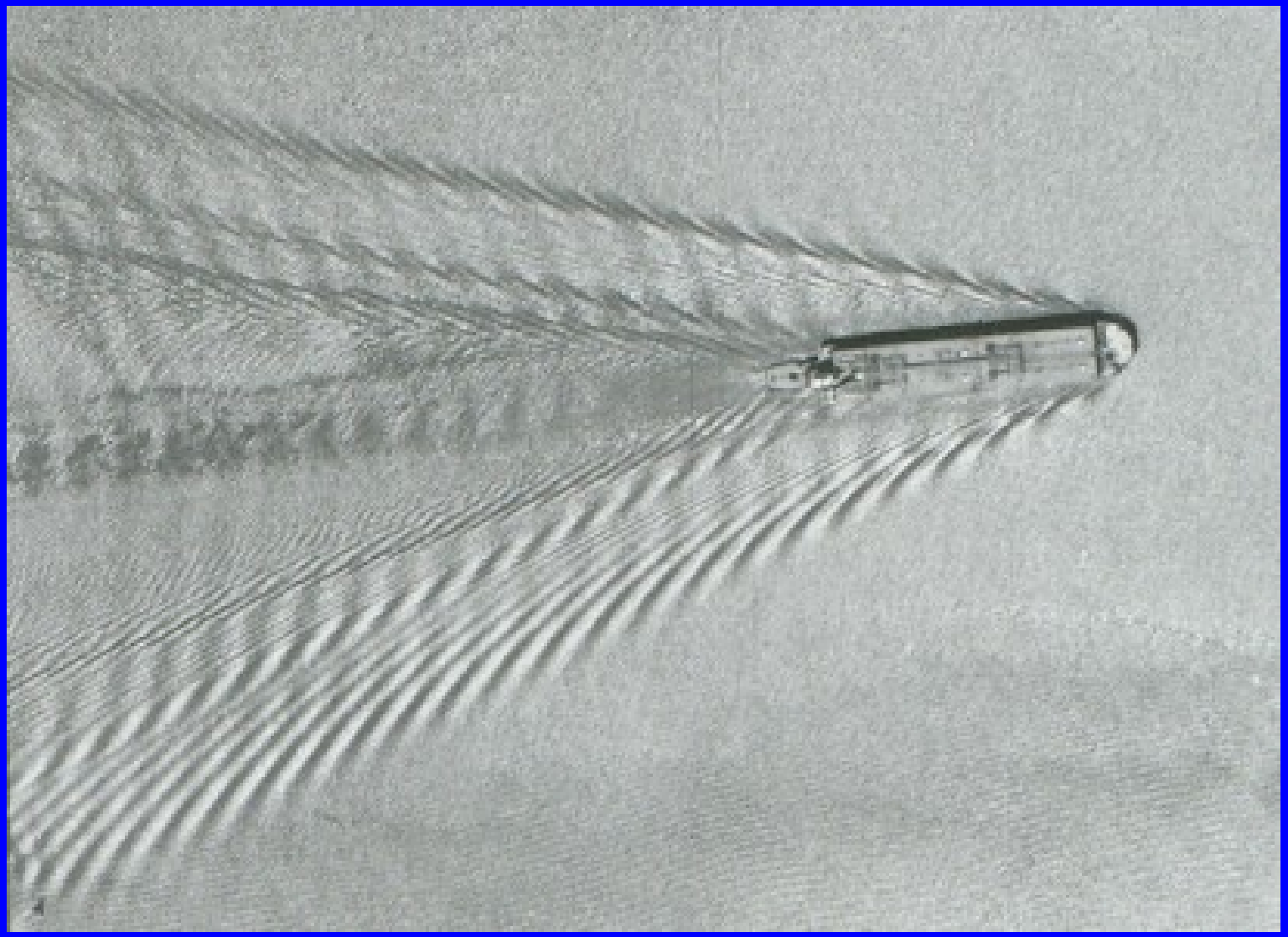
Return Velocity



Sabine River Event 18
S/R Charleston In
Speed 15.6 ft/sec

Short Period Effects

Secondary Waves at Bow and Stern



Surge Waves (Dand and White, 1978)

- Surge waves result from drawdown effects in channels with shallow (1-2 m deep) berm.
- Surge waves increase with shallow water depth over berm, increased ship speed, and increased drawdown

Surge Waves, Sabine Neches

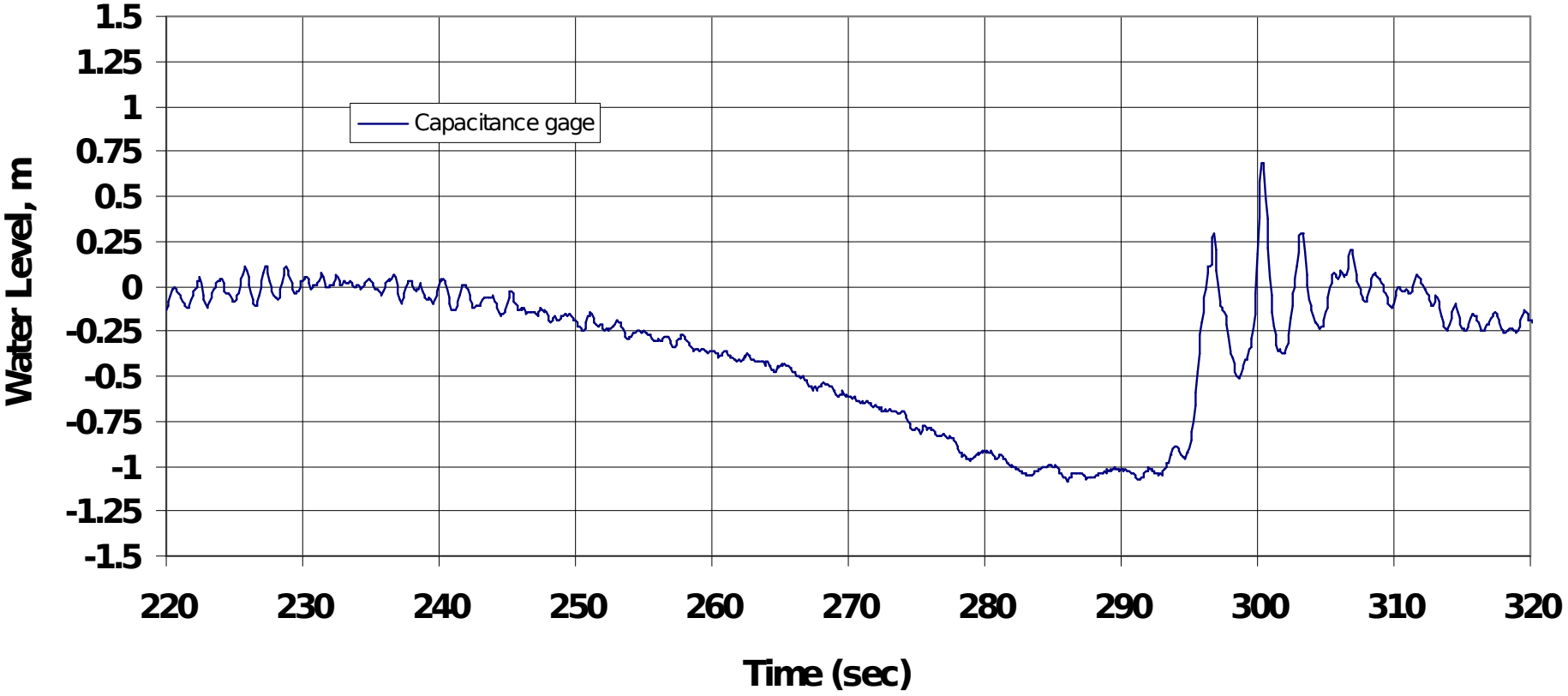
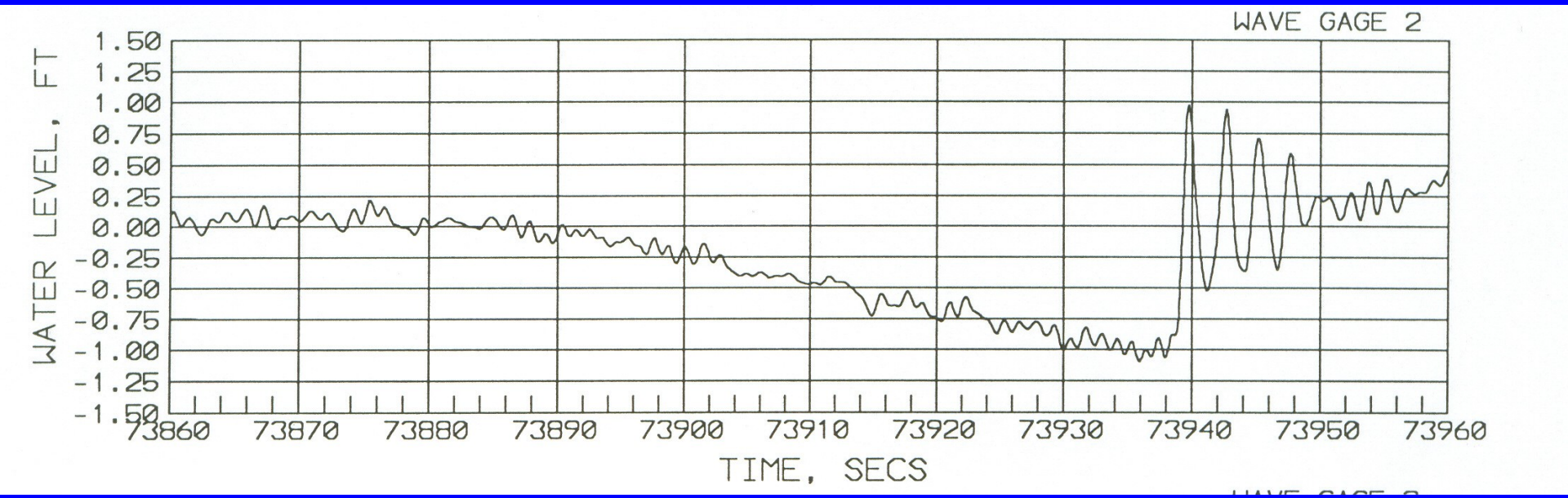


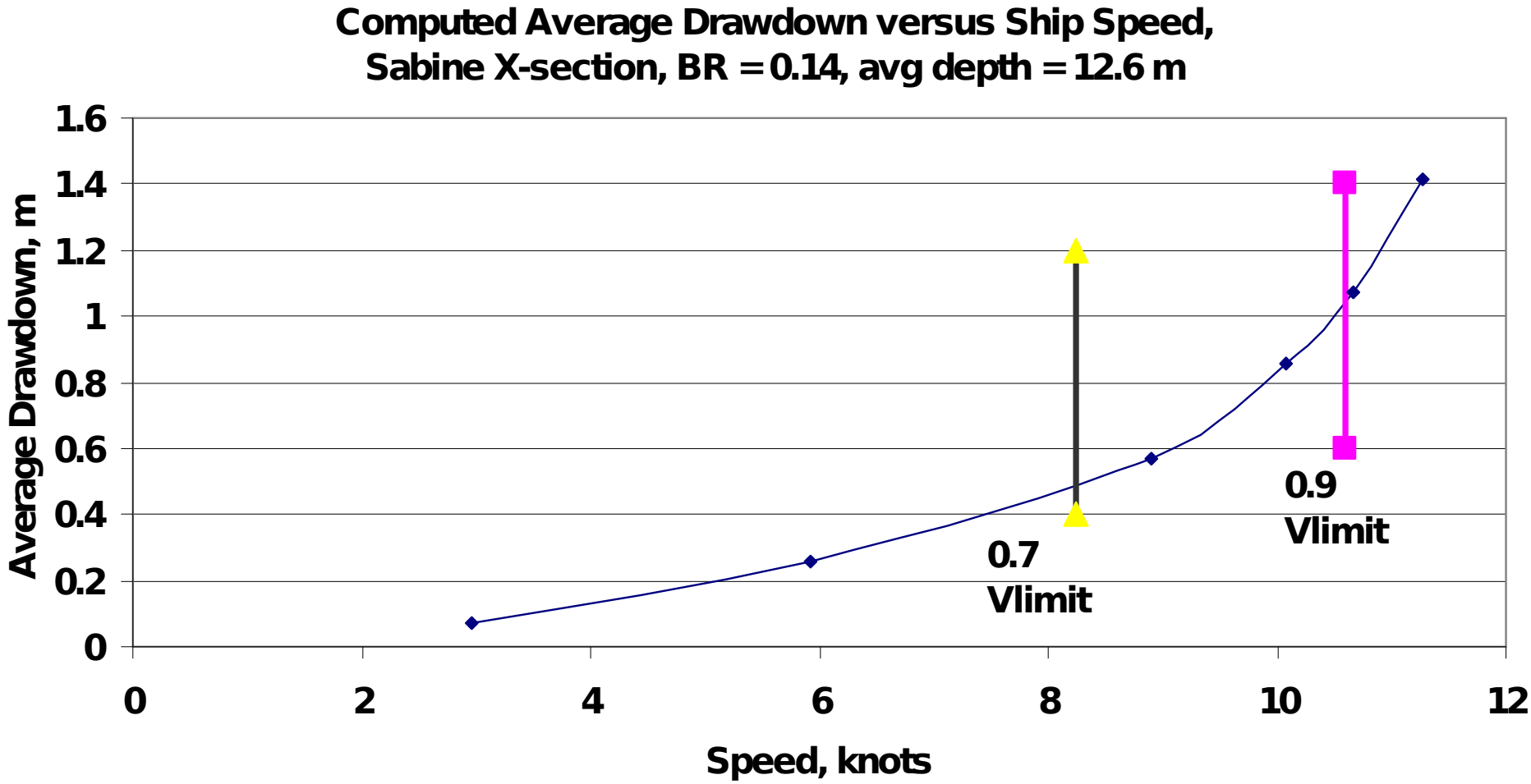
Figure __. Water Level for Pacific Sapphire, Inbound, Time 0 = 1300, 1 May 2002, Near-channel Capacitance Gage 1200522b, Existing Channel, South Site.

Surge Waves, HSC

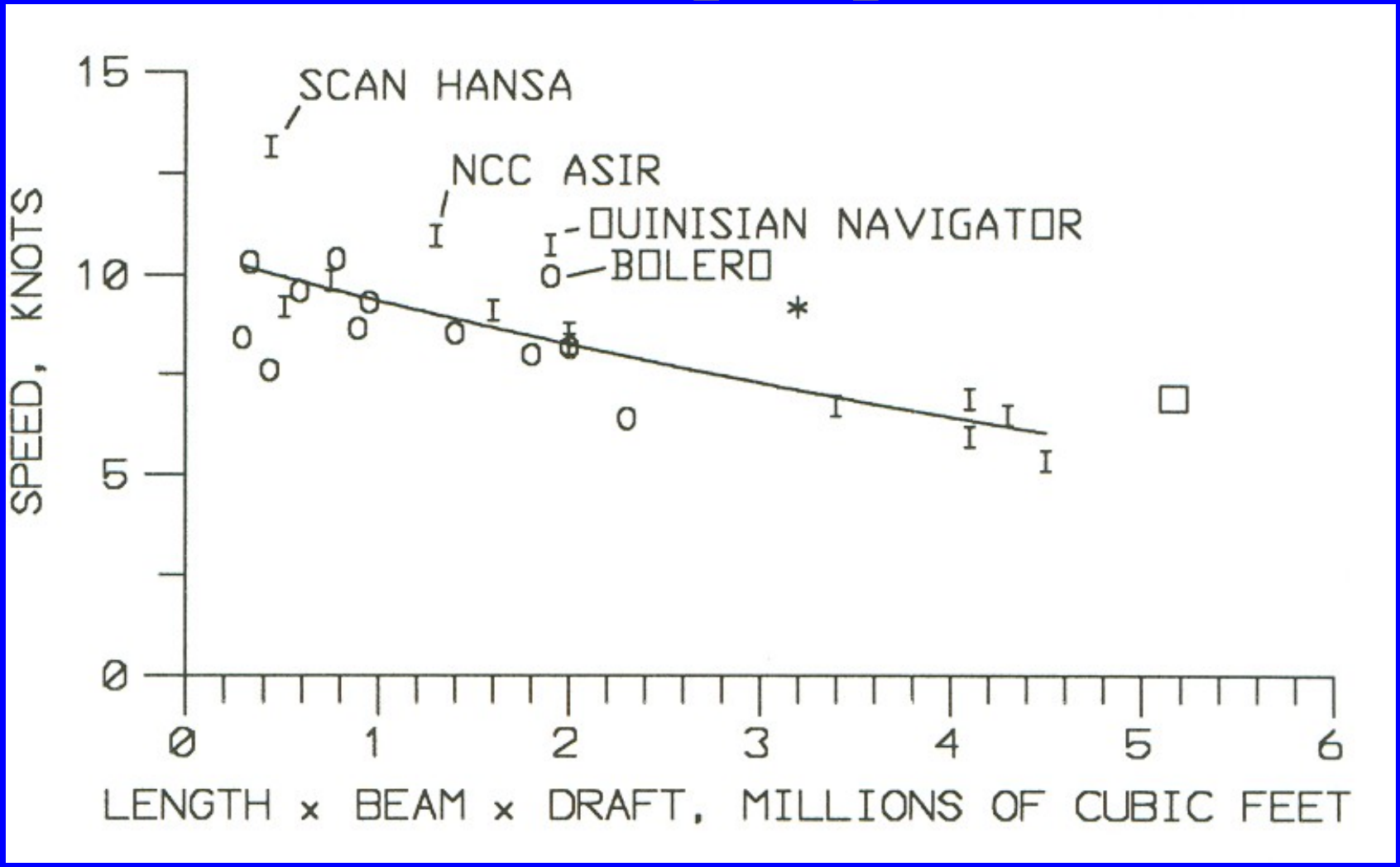


Ship Speed = Critical

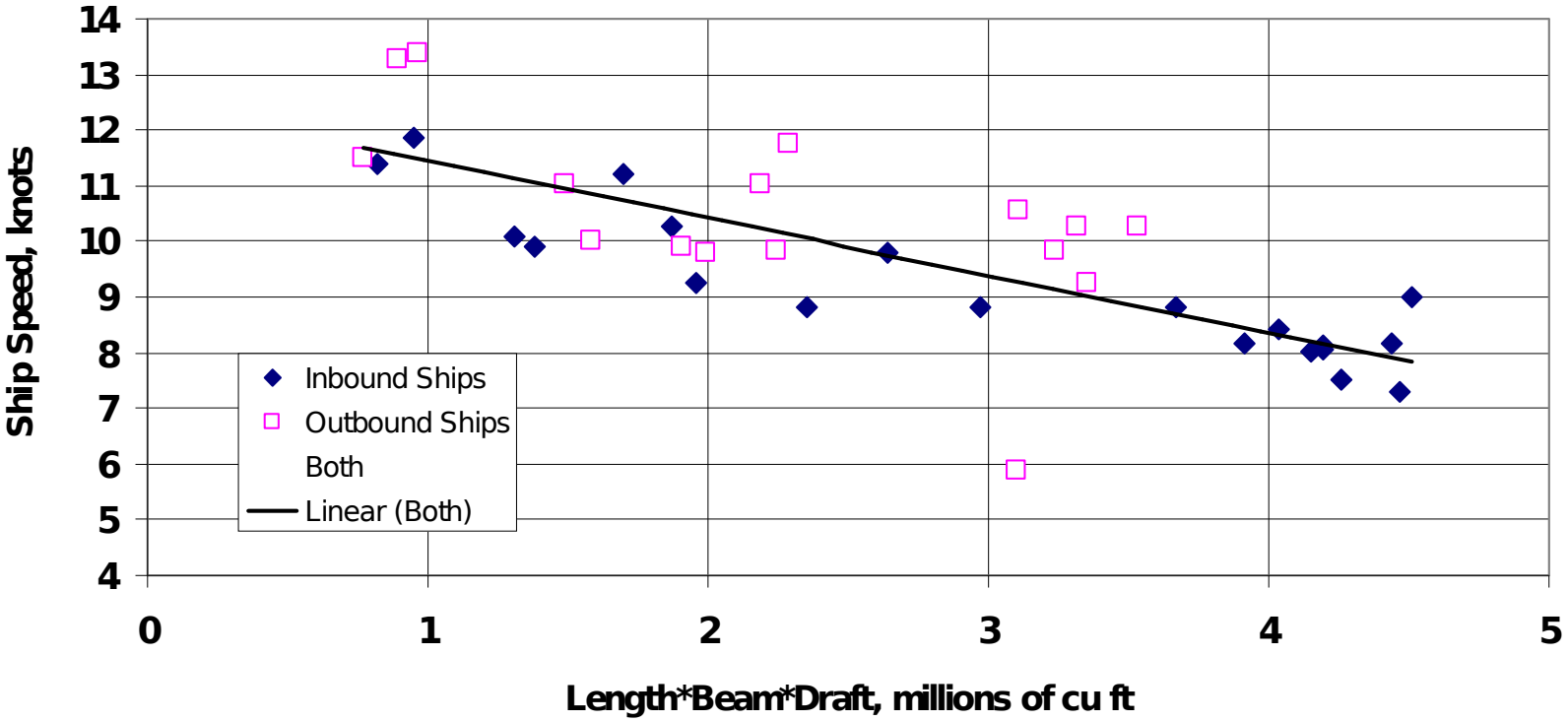
- In confined channels, ship speed is critical in defining bank effects
- Ships generally operating at 70-90% of limiting speed
- Ship effects increase rapidly with speed
- Ship speed difficult to define for proposed ships in proposed channels

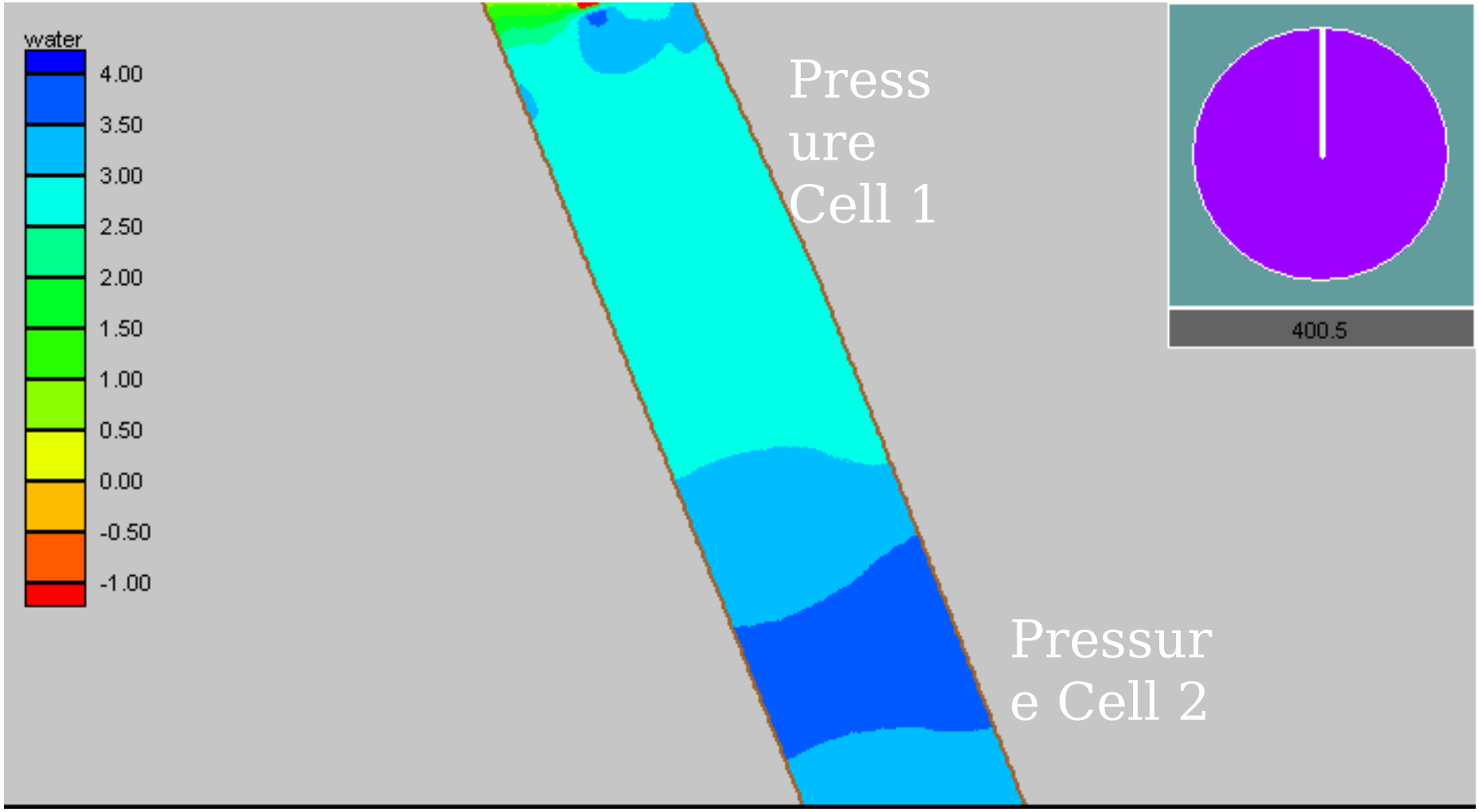

Computed Average Drawdown versus Ship Speed,
Sabine X-section, BR = 0.14, avg depth = 12.6 m
Average Drawdown, m
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
Speed, knots
0.7
Vlimit
0.9
Vlimit

HSC Ship Speeds



Sabine Neches Speeds




water
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
Press
ure
Cell 1
400.5
Pressur
e Cell 2

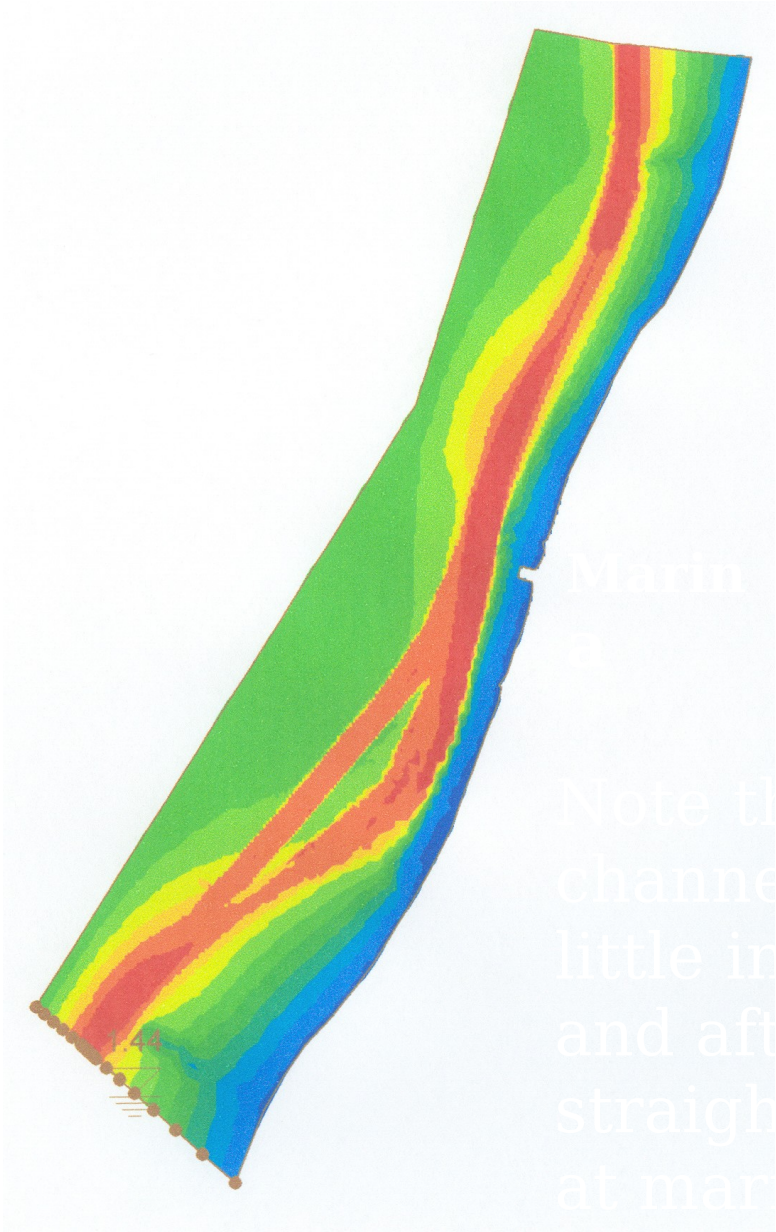
Determining Ship Speed cont'

- Drawdown arrival at gages and distance
  - Sabine Neches-fair, MRGO-poor
- Stop watch and two points at known distance- HSC
- Stop watch and ship length- must be on-site
- Time-lapse video camera and ship length- best, can even work at night

Ship Speed Concluded

- Ship speed in HSC and Sabine for largest ships generally less than 12 knots.
- Generally less than 14 knots at mixed channel like Tolchester.
- Secondary waves at bow and stern generally not dominant bank loading at these speeds.
- Displacement effects causing drawdown, surge, transverse stern wave, return velocity, and surge waves are dominant bank loading in these channels.

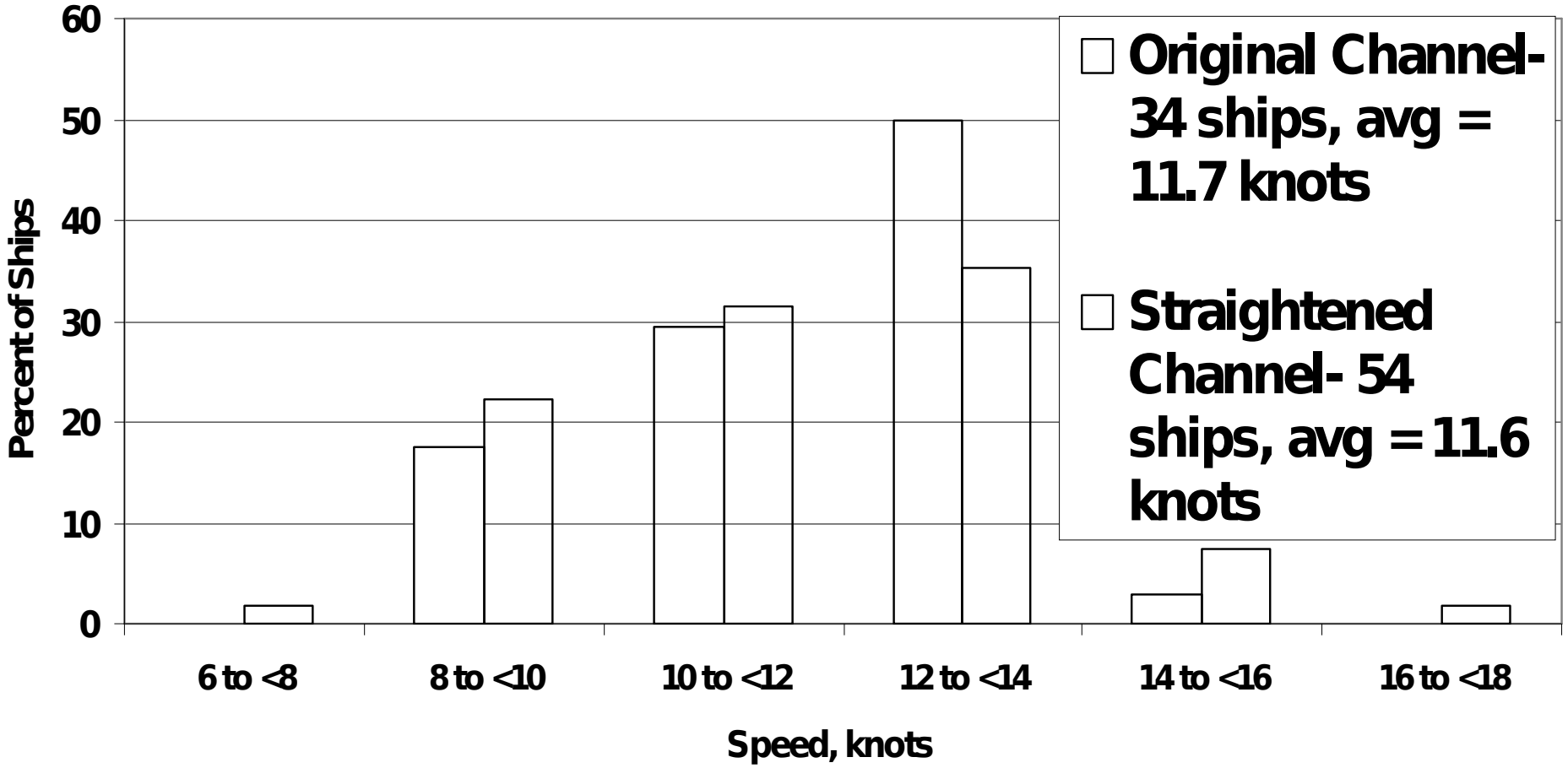
Case Study, Tolchester

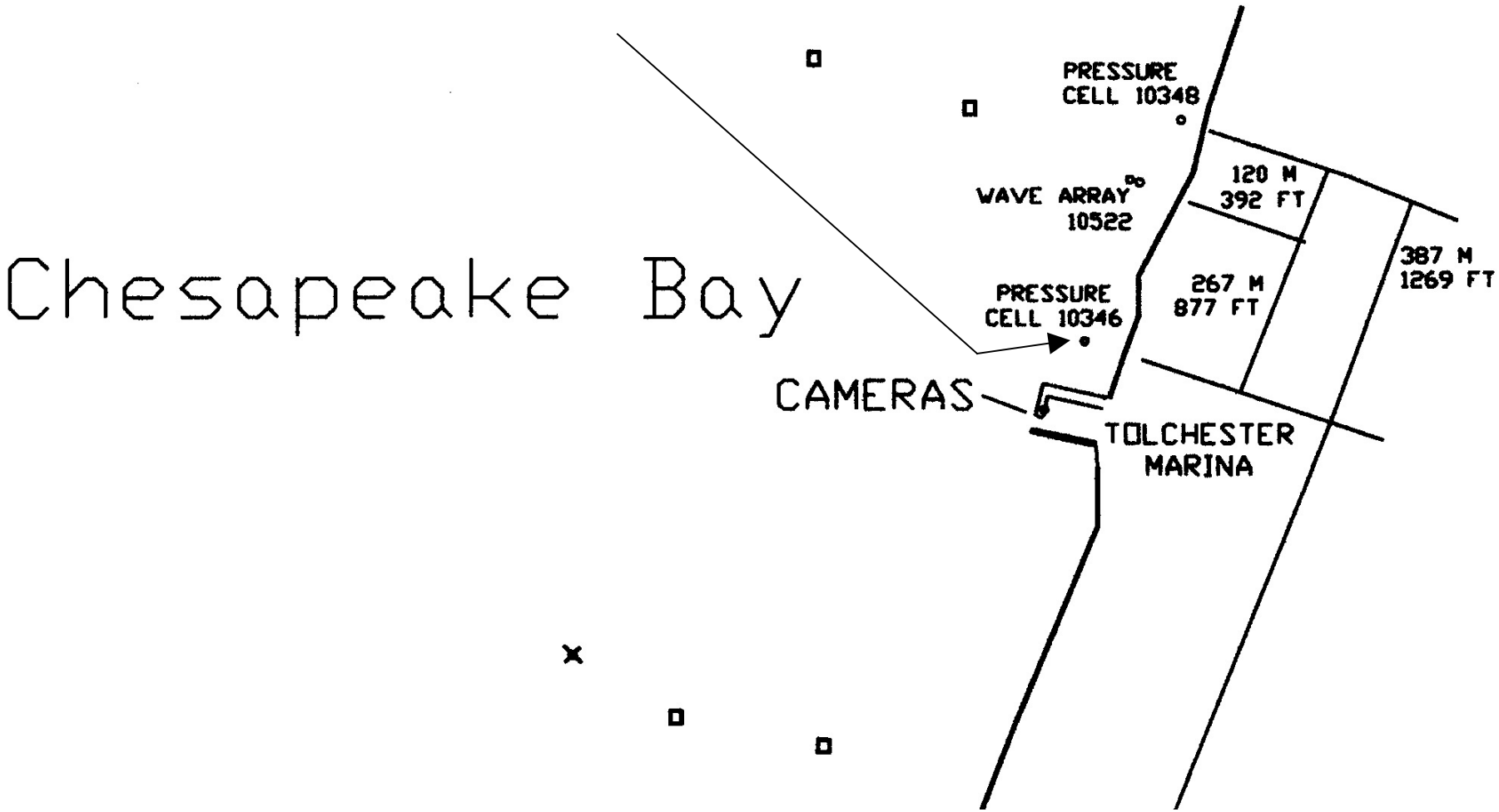


Tolchester

- Objectives- Bank forces and safety in before and after straightening channels.
- Before straightening field study- Oct-Dec 2001
- After straightening field study- June-Aug 2002
- HIVEL2D simulations

Did Speeds Increase?




Chesapeake Bay
PRESSURE
CELL 10348
WAVE ARRAY
10522
120 M
392 FT
387 M
1269 FT
267 M
877 FT
PRESSURE
CELL 10346
CAMERAS
TOLCHESTER
MARINA

Observed Water Level, Point B

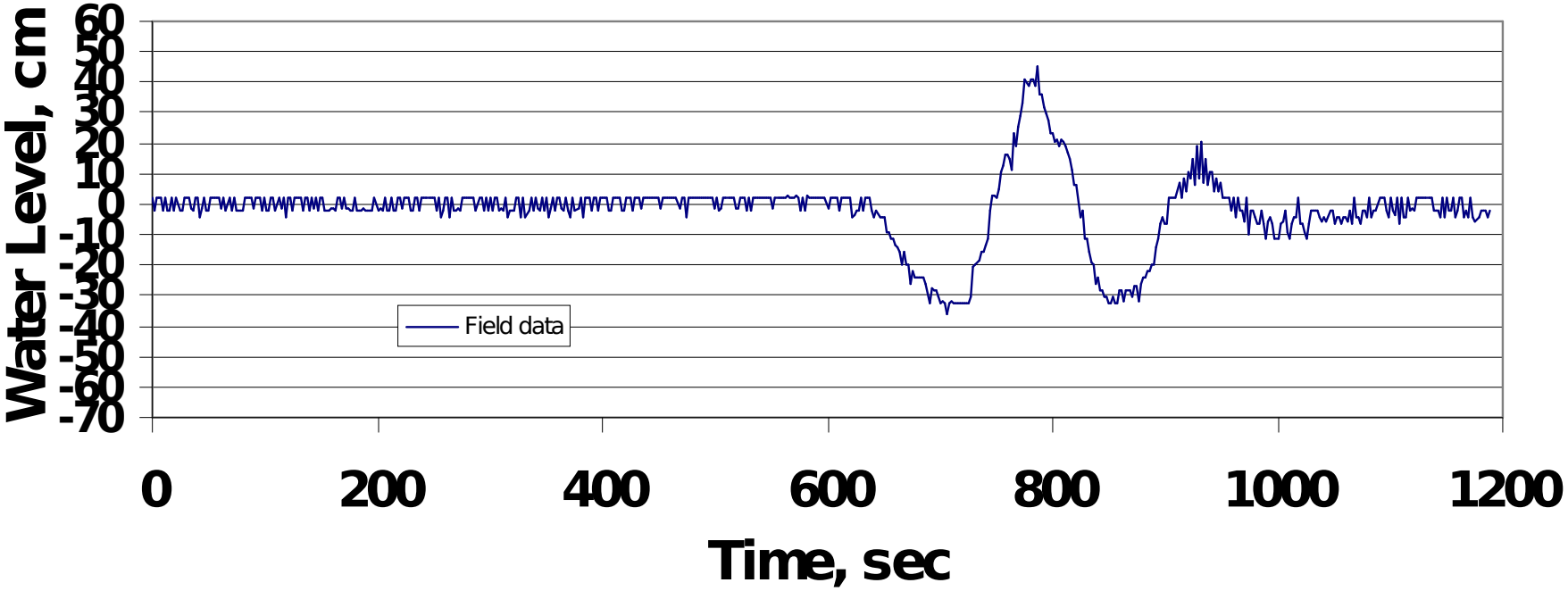


Figure . Jinsei Maru, Time 0 = 2340 EST, 2 Nov 01, pressure cell , Original Channel, file TOL_1009_ORIG, Point B.

T
WARNING
BEWARE OF
SHIPS WAKES
NOT RESPONSIBLE FOR
INJURIES OR LOSSES

Safety Issue

HIVEL2D Simulations (Stockstill and Berger, 2001)

- Finite element, 2D shallow water equations in conservative form
- Vessel effects modeled using a moving pressure field to represent the ship’s displacement

Observed vs Computed, Point B

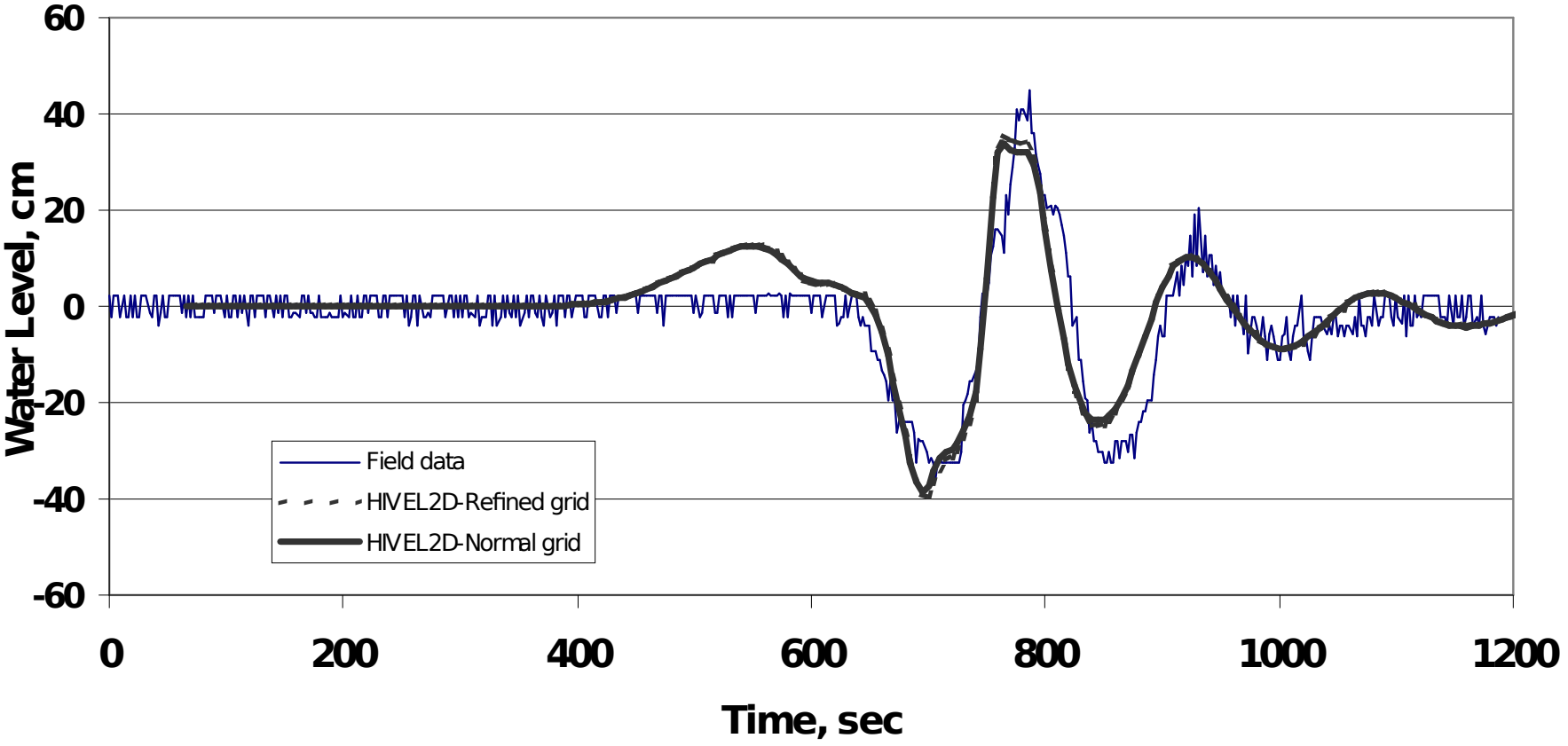
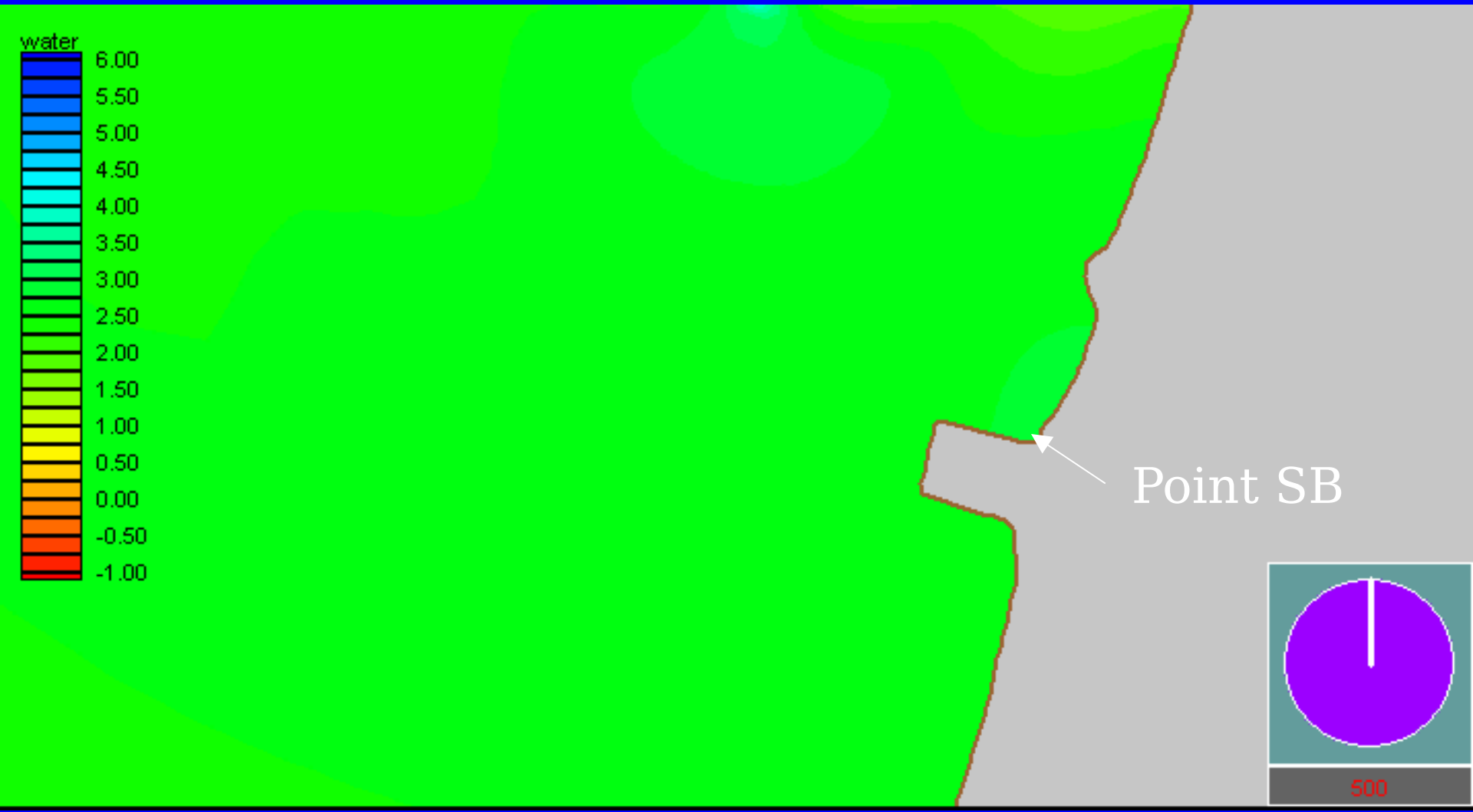


Figure . Jinsei Maru, Time 0 = 2340 EST, 2 Nov 01, pressure cell 10347 and HIVEL2D, Original Channel, file TOL_1009_ORIG, Point B, node 18708 in normal grid, node 22734 in refined grid.

Design ship, 813 X 106 X 31.2 ,
12.2 knots,

Ambient Water Level = 2.2 ft



Effect of Speed on Water Level at Point SB

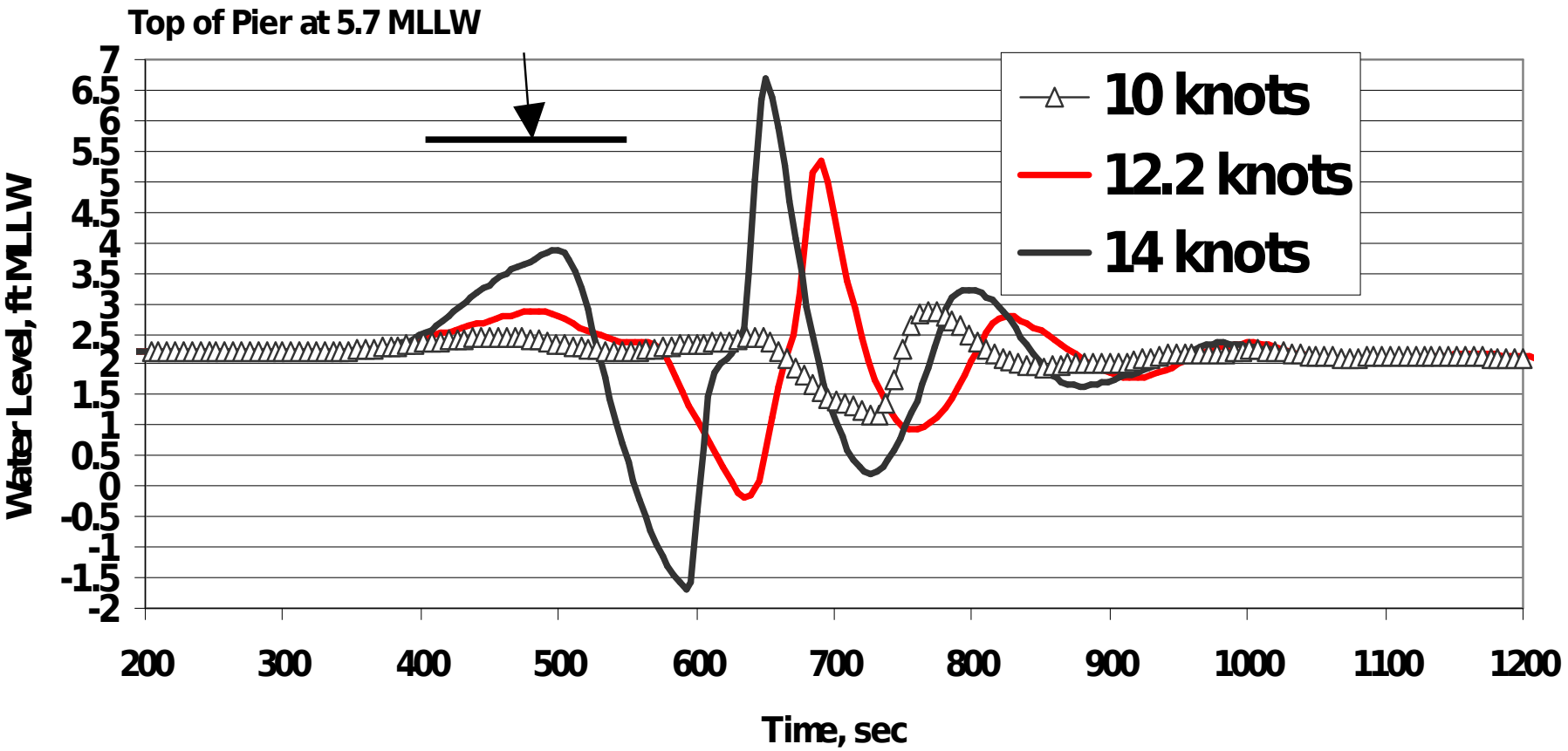
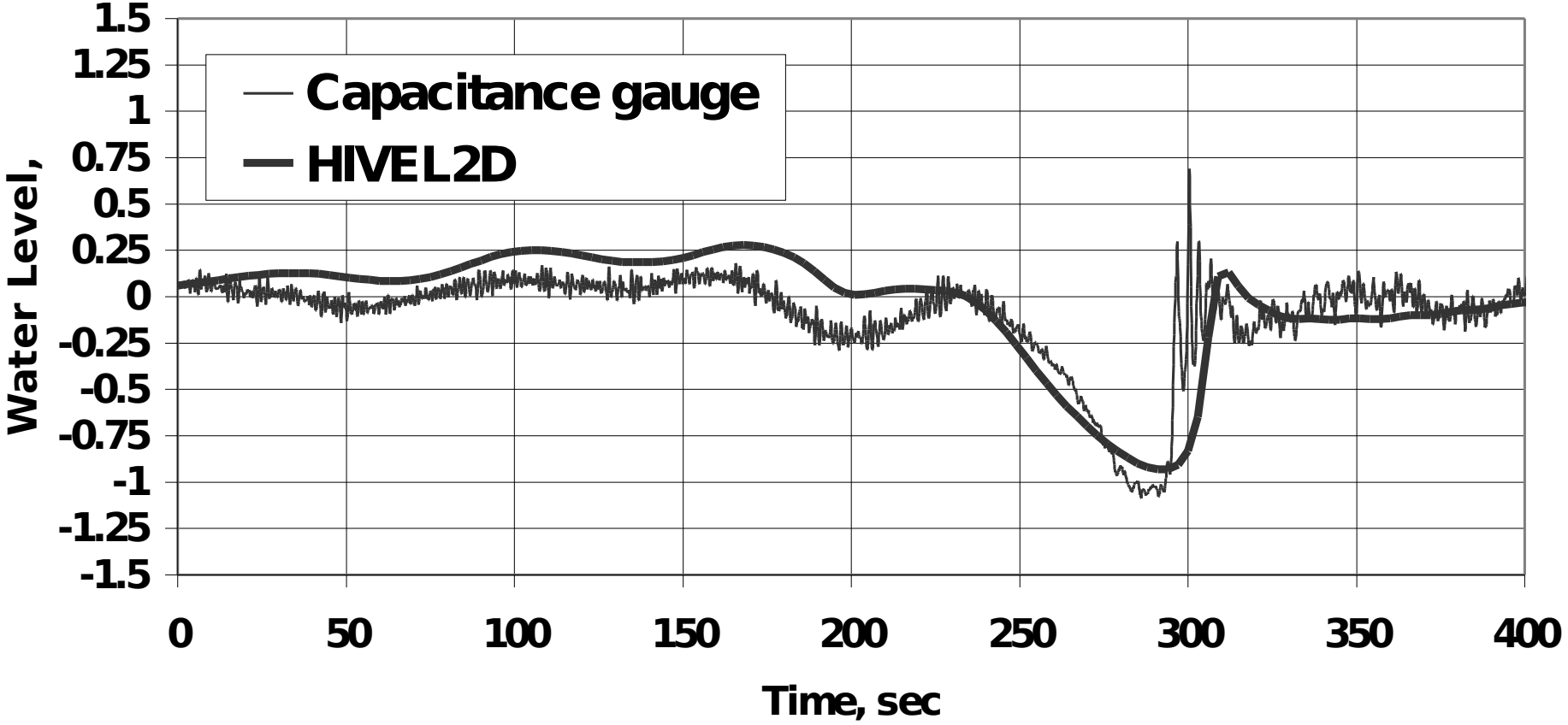


Figure . Computed Water level at shoreline Point SB, node 17558, straightened channel, design ship, effect of speed

HIVEL2D- Sabine Neches



Atkinson Island- 50 Ships/day

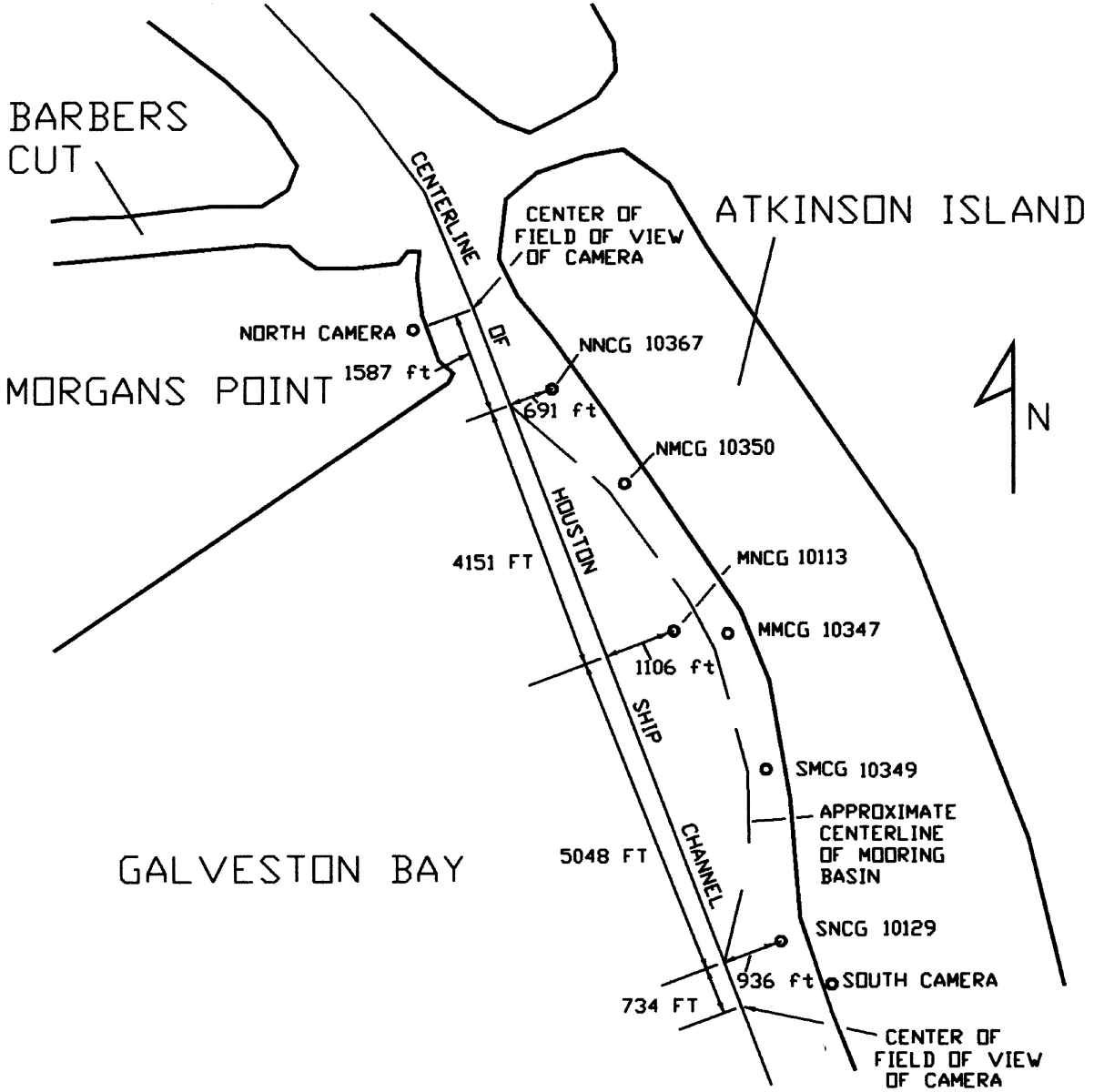


FIGURE 1. SCHEMATIC OF GAGE AND CAMERA LOCATIONS

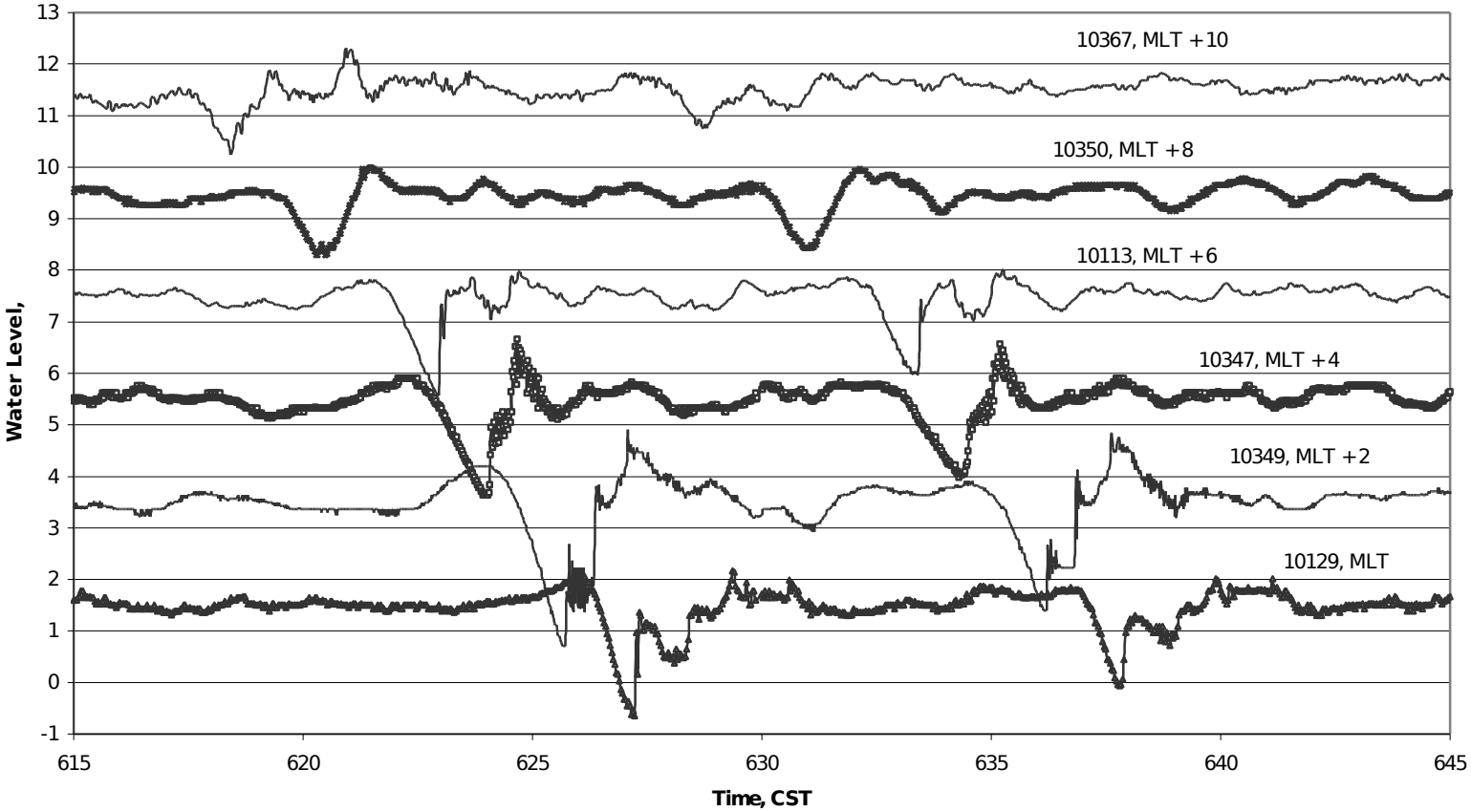
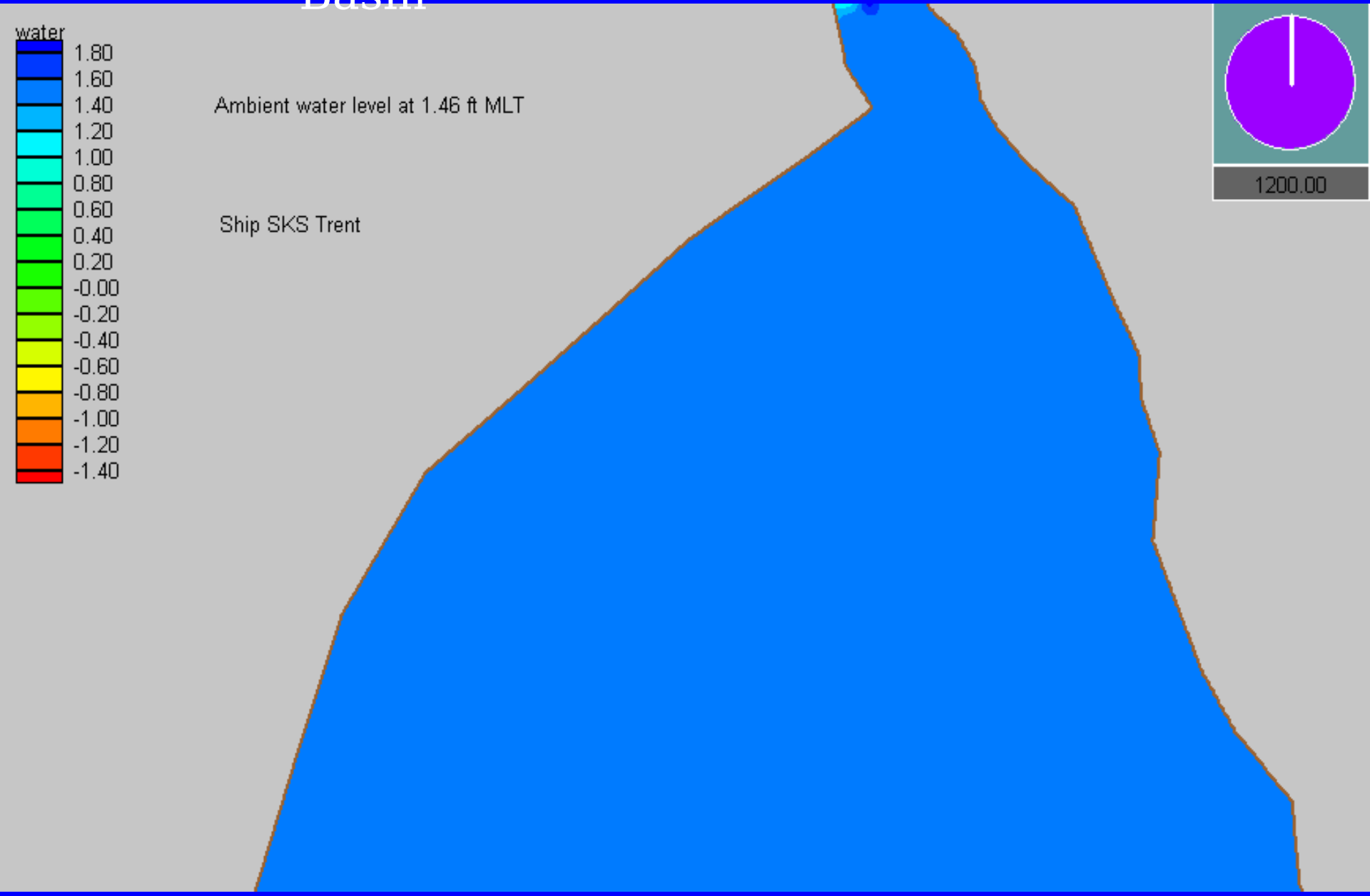


Figure 12. SKS Trent and Gaz Progress, Outbound Ships, All Gages, 6/5/2003

HIVEL2D- Atkinson Island Mooring Basin



Questions?